**GSA Public Building Service** 



**FINDINGS, DECEMBER 2012** 

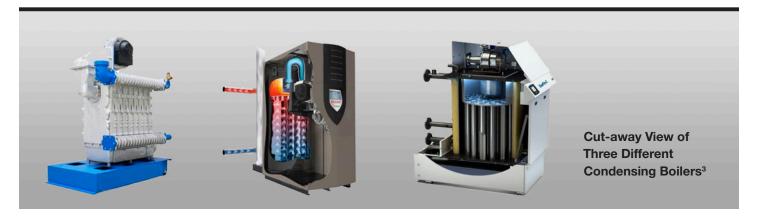
# CONDENSING BOILERS



# Condensing Boilers Reduce Heating Energy Consumption

Heating accounts for 35% of total energy consumption in this country's commercial buildings, according to the U.S. Energy Information Administration (EIA)<sup>1</sup>. There are several ways to provide heating in commercial buildings, with boilers among the most common. The Commercial Buildings Energy Consumption Survey (CBECS) estimates that boilers are used in 32% of commercial buildings, and the EIA claims that boilers heat 34.5% of total heated floor space<sup>2</sup>. Considering GSA's own reliance on boilers for heating, the Green Proving Ground (GPG) program recently assessed the performance of condensing boilers at the Peachtree Summit Federal Building, a 31-story office building in Atlanta, Georgia. Condensing boilers extract more of the heat energy released by the combustion process than do conventional boilers and are therefore more efficient. Under the right conditions, they will outperform conventional boilers by a substantial margin. This was found to be true at Peachtree, where the condensing boiler plant assessed during the period of study reduced natural gas consumption by an estimated 14%.

## INTRODUCTION



"Condensing boilers reduced our natural gas consumption by 14%, putting us that much closer to meeting our EISA mandate."

Roderick Grant,
Property Manager
Peachtree Summit Federal Building
Atlanta, Georgia
GSA

## What We Did

### RESEARCHERS AMASSED DATA OVER SIX-MONTH PERIOD

In 2010, two natural-gas-fired conventional boilers, which had reached the end of their useful service, were removed from the penthouse mechanical room of the Peachtree Summit Federal Building and replaced with four natural-gas-fired condensing boilers. Overall capacity of the heating plant remained the same. In 2011, GPG commissioned the Pacific Northwest National Laboratory (PNNL) to assess the new heating plant's performance. Peachtree's condensing boiler plant was monitored for approximately 6 months, from December 14, 2011 to May 11, 2011. The objective was to quantify the plant's performance and the load profile for the building application, to estimate the normalized energy savings and compare them to what would be expected from a conventional non-condensing-boiler heating plant, and finally to assess the technology's broader application within the GSA portfolio.

## What We Measured

# PERFORMANCE DATA WAS MEASURED AGAINST "NAMEPLATE" EFFICIENCY RATING

Data from meters and sensors were collected through an independent data acquisition system (DAS). In addition to monitoring the boiler plant's output, fuel consumption was measured and recorded. The stored data were used to determine both the performance profile of the boiler heating plant and a heating load profile model for the building. The boiler plant performance profile, building heating load model, and typical meteorological year (TMY) data were used to estimate normalized energy savings associated with the condensing boiler system. Because PNNL's assessment began a year after the conventional boilers were replaced with condensing boilers, researchers did not have the opportunity to assess the original baseline conditions. For this reason, the measured performance of the condensing boilers was compared to a nominal 80% efficiency rating for a conventional noncondensing boiler system.

## **FINDINGS**



**REDUCTION IN ENERGY CONSUMPTION** On a weather-normalized basis, condensing boilers reduced Peachtree's natural gas consumption from 92,033 therms/yr to 79,014 therms/yr, or 14%. Similar reductions from the application of condensing boilers throughout GSA's portfolio would result in a savings of between 0.7% and 1.0% of GSA's FY2007 total energy consumption, assuming that space heating accounts for 35% of GSA's annual energy consumption and that boilers provide space heating in 34.5% of GSA facilities.



**TYPICAL PAYBACK OF UNDER 5 YEARS** While simple payback for the boiler plant at Peachtree was assessed at 9.9 years—this due largely to unique circumstances that increased installation costs—typical condensing boiler payback was assessed at less than 5 years. Low simple payback assumes that conventional boilers would otherwise be replaced with a high efficiency boiler as required by GSA's Facilities Standards at end-of-life. Retrofitting a conventional boiler heating plant with condensing boilers, when conventional boilers still have considerable useful life remaining, is not as cost-effective. Higher utility costs and lower installation costs would further reduce simple payback.



**LOW O&M COSTS** Increase in operations and maintenance (O&M) costs for condensing boilers was found to be negligible. Condensing boilers typically require the installation of condensate neutralizers. They should be replaced or recharged annually at a cost of approximately \$100 per boiler.



**PORTFOLIO-WIDE END-OF-LIFE DEPLOYMENT RECOMMENDED** Condensing boilers at Peachtree demonstrated a clear advantage over the conventional boilers they replaced. Energy savings were comparatively high and simple payback low. Replacing conventional boilers that are at end-of-life with condensing boilers should be considered during all facility energy audits.

## Condensing Boilers Deliver Low End-of-Life Payback

Average payback for four 2,500 MBtu condensing boilers is 3.7 years

	PEACHTREE		AVERAGE COSTS (FOUR 2,500 MBtu BOILERS)*		
	High-Efficiency Boilers	Condensing Boilers	High-Efficiency Boilers	Condensing Boilers	
Installed Cost	\$659,100	\$729,755	\$384,800	\$426,100	
Energy Cost/yr	\$70,209	\$63,053	\$81,604	\$70,179	
Additional Maintenance/yr		\$400		\$400	
Simple Payback at End-of-Life		9.9		3.7	

<sup>\*</sup>Assuming average installed cost of \$38.50/MBtu for FEMP designated product minimum performance requirement of 84% and \$42.60/MBtu for condensing boilers and \$0.887/therm energy costs based on the 2012 GSA portfolio average.

# CONCLUSIONS

These Findings are based on the report, "Condensing Boiler Assessment: Peachtree Summit Federal Building, Atlanta, Georgia" which is available from the GPG program website, www.gsa.gov/gpg

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#### Footnotes

<sup>1</sup>EIA 2003b. Commercial Buildings Energy Consumption Survey: Energy End-Use Consumption Tables, Table E.1. Major Fuel Consumption (Btu) by End Use for Non-Mall Buildings, 2003, U.S. Energy Information Administration, Washington, DC. Accessed 07/05/2012 http://www.eia.gov/emeu/cbecs/cbecs2003/detailed\_tables\_2003/ 2003set19/2003pdf/e1-e11.pdf

<sup>2</sup>ibid

<sup>3</sup>Images courtesy of Harsco Industrial Patterson-Kelley, Lochinvar, and Cleaver Brooks, [from left to right, respectively], used with permission.

### What We Concluded

#### **FAVORABLE RESULTS DEPEND ON PROPER APPLICATION AND OPERATION**

At the Peachtree Summit Federal Building, condensing boilers outperformed estimates of conventional boiler performance by margins consistent with expectations set by their respective thermal efficiency ratings. Their superior performance depended, however, on the heating plant's design and operation, which, in the case of Peachtree, was very good though not above improvement. Favorable results in other settings will depend just as greatly on the proper application of the technology, including accurate thermal load calculations, which ensure that the plant is designed to meet the thermal load without excessive overcapacity.

## Lessons Learned

# LOW ENTERING WATER TEMPERATURES ENSURE CONDENSING BOILER EFFICIENCY

Condensing boilers do not always operate in condensing mode, though high efficiency is achieved only when they do. This generally requires an entering water temperature of between 120°F and 130°F. It is important, therefore, to reduce the hot water return temperature whenever possible and to the maximum extent possible. For retrofit applications, this can be accomplished by reducing the hot water supply temperature, when the thermal load allows. Return temperature reduction may also be accomplished by reducing the hot water flow rate (again when the load allows), thereby increasing the temperature drop through the heating coils. In new construction, designers may consider selecting heating coils that can deliver specified heat loads with lower hot water supply temperatures, as well as increased temperature drop through the heating coils. Also for new construction projects, it may be cost effective to select heating coils specifically designed to improve the operation of a condensing boiler plant.

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